Energy Efficient Building Report

Watts up?

This year, we have chosen a class called advanced tech. Our first major project was to build an energy efficient building and compete in a competition against other schools to see whose building is the most energy and cost efficient. We were given various guidelines that we had to meet for building the shed. At the competition, a few members of our class will be staying in the shack all night and playing video games.

How it started

To get all of our tasks accomplished we split into three groups of three and joined up with the framing and sheathing class. As a class, we had a discussion and decided what we wanted our building to look like. After the blueprints were complete, we presented this idea to the framing and sheathing class and they set to work constructing our building. Meanwhile; we formed our groups and assigned tasks. One group was in charge of the solar hot water heaters and the solar electric panels; Allie, Justin and Bryce were in this group. Another group was responsible for finding out which insulation would be the most efficient and designing the blueprints. Laura, Chad and Ira were in this group. The last group was in charge of designing and building an air exchanger and finding out which video game system and television was the most efficient, Micah, Brandon and Liam were in this group.

The group that was making the solar hot water heaters and solar electric heaters built two new heaters and then used one from last year. They painted one of the solar panels flat black, one of the panels gloss black and covered one of them with aluminum foil.

We have tested all three of the solar hot water heaters. It took us a while to actually start our testing because the water leaks. The water would leak out of where the hose would connect to the bucket and also where two hoses connect to each other. After a lot of altering, we finally got them to stop leaking and got some data, our findings are in graph below.

INSERT GRAPH HERE

The group that designed and constructed the solar hot water panels was also in charge of wiring up the solar electric panels, I have included a small table showing the light intensity and how much current it creates.

Light Intensity (Lux)	Current (amps)
100600	2.5
111000	3
33000	0.6

Keeping it Fresh

In our guidelines, it showed that to keep the air fresh inside our building that we would have to exchange one third of it every hour. After many tries and test runs we seem to have developed a good system. First the air gets sucked in through the window and pushed through a system made of straws. The straws are placed across another set of straws containing heated air. The air then gets blown through tubing that is immersed in hot water. The heat from the water is transferred in to the air via contact. It is then blown into the room, exchanging the air, while keeping a constant temperature.

Entertainment System Testing

The group that created and designed the air exchanger was also in charge of testing and choosing what video gaming system and television was the most efficient. They sent watts up meters home with all of the groups and our classmates tested their televisions and gaming systems. They gathered up all of the information and put it in the form of a table. They then determined that the 32 inch LCD television put on power save mode and the xbox 360 were the most energy efficient. To power our electronics we have batteries that will be charged by the sun on the day of the competition. To the right there is a table showing the results of the tests.

Game System	Power (w)	Voltage (v)	Current (A)
Wii	144	120	1.2
xbox	135	120	1.13
Game Cube	132	120	1.1
PS3	174	120	1.45
PS2	141.6	120	1.18
N64	116.4	120	0.97
50 inch Plasma	253	120	2.1
15 inch TV	100.8	120	0.84
32 inch LCD	204	120	1.70
27 inch TV	117.6	120	0.98

Insulation Testing

The last group was in charge of finding out which insulation would be the most efficient environmentally and economically. We tested the heat loss four times, one with fibreglass pink insulation, recyclable insulation, one with straw and one with no insulation so we would have something to base our results off of.

We discovered the R-Value using these formulas:

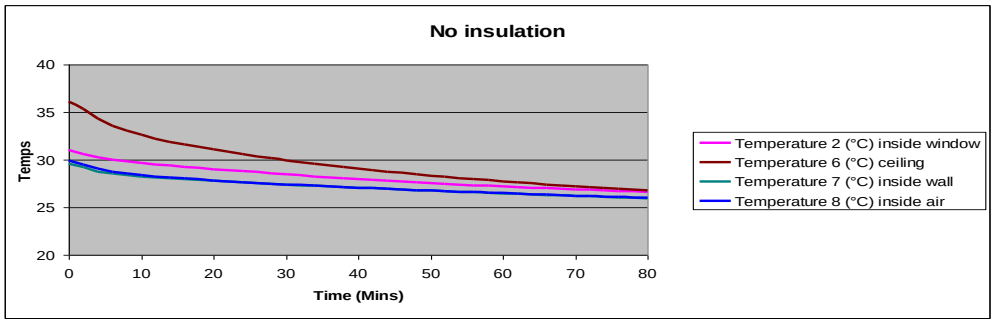
Q - Heat lost in joules
m - Mass of air in the room, therefore density
C - Specific heat of substance used for insulation
ΔT - Change in temperature
t - Time

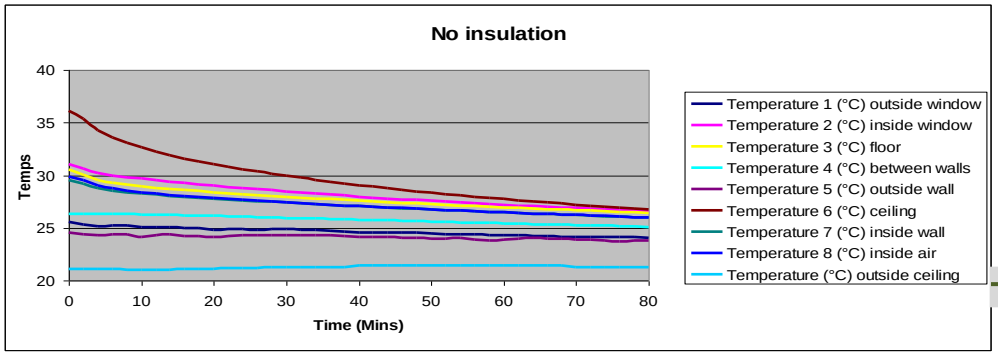
$$Q = \frac{mc\Delta T}{t}$$

R – Thermal insulation value in $m^2 \cdot k \cdot s$ / j.
A – Surface area between the hot body and the cold body in m^2
Q – Transfer of heat from hot body o cold in jouls per second
T_{hot} -T_{cold} – Average indoor temperature minus the outdoor temperature

$$R = \frac{A(THot - TCold}{Q}$$

We tested the Building with no insulation to see if it had an r-value and so we would have something to base our other results off of. The information we found if displayed in the graph below.

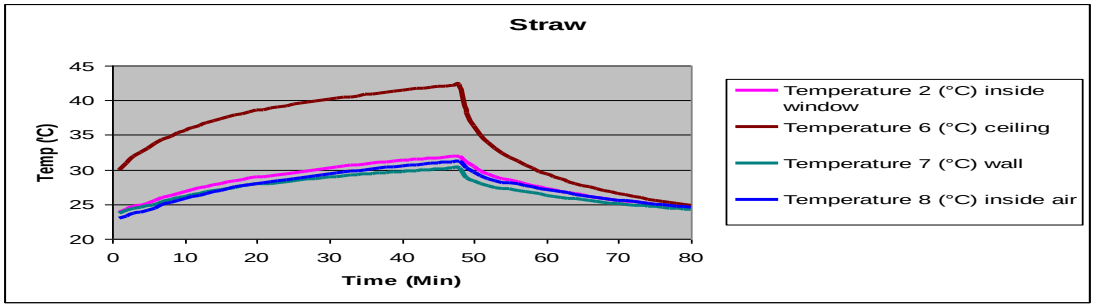


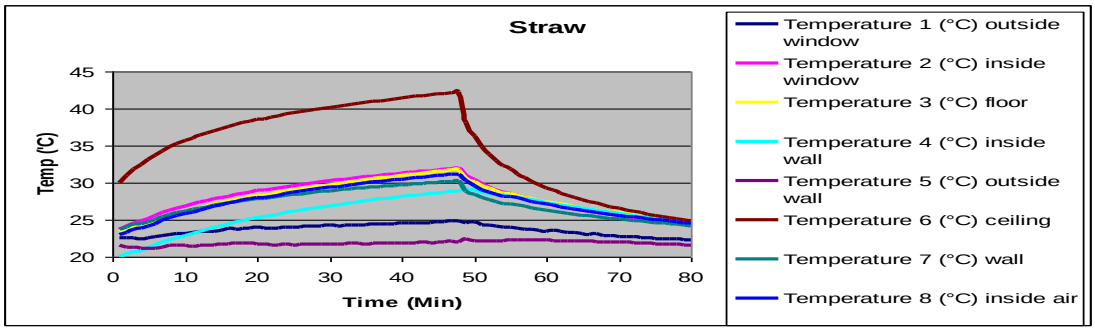


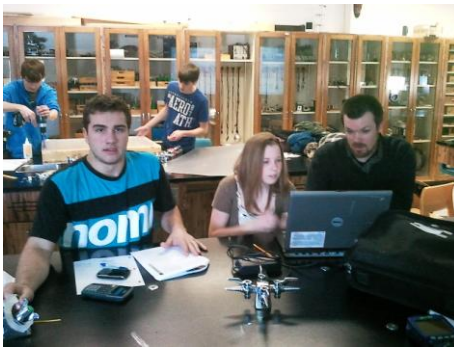
By looking at the graph above we can see that we need to target the ceiling, around the windows and inside the walls because they lose the most heat. We realized that the ceiling needed extra insulation because it was the steepest point and all of the hot air rose and the escaped from the roof.

Q = (0.2090016)(1.29)(1.006)(5.17)(0.04308)
Q = 0.060409263

R = 0.1646(5.17) / 0.060409263
R = 14.08







We wanted to test straw because it's very environmentally friendly and economically friendly. We researched some information and found out that they use bales of straw in home to insulate today. Also, we figured that straw would be the easiest to obtain out of all the other environmentally products. We placed the straw in the miniature building. Our graphs above display what we found.

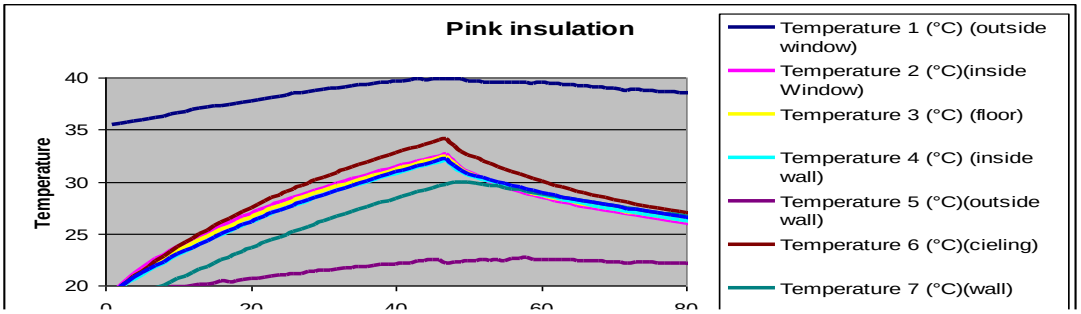
By looking at the graph alone, we could tell that the heat did not escape as quickly. The slope was not as steep as it was for no insulation.

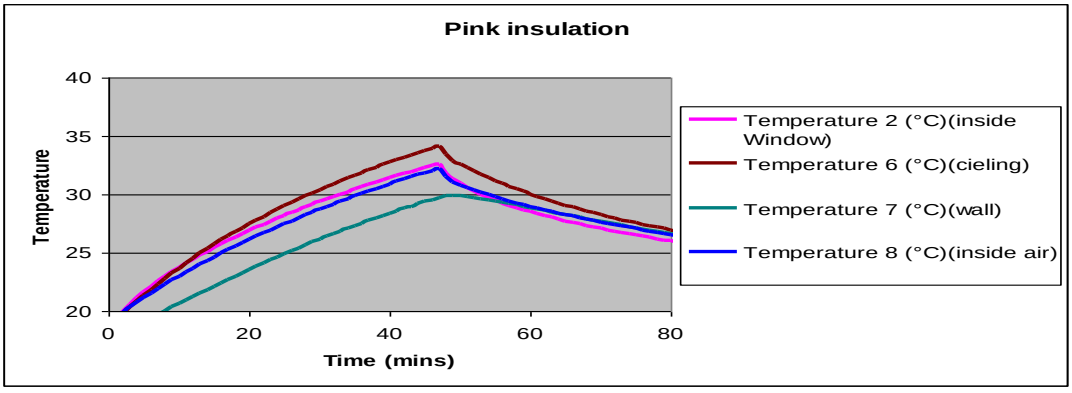
Q = (0.2090016)(4.2313x10^-5)(1.006)(5.15)(0.0429)
Q = 0.04581721

R = 0.1646(5.15) / 0.04581721
R = 18.49

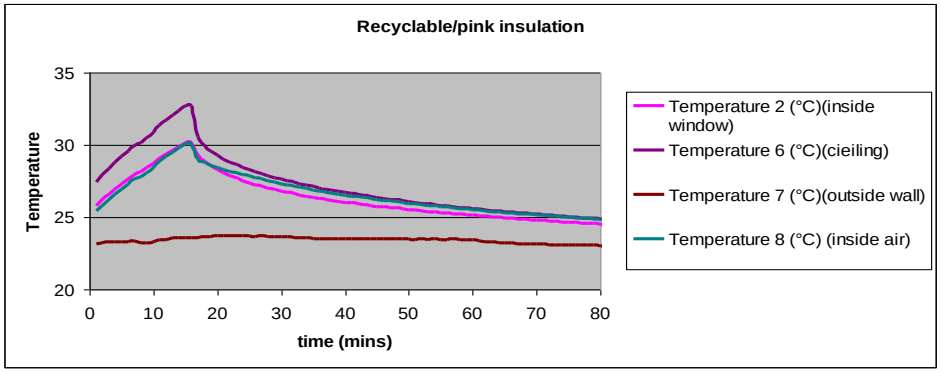
We tested the pink insulation because it is the most commonly used. From the graph below we can see that it is the most efficient so far. The pink insulation would cost around $210, so it is much more expensive than the straw would be. The pink insulation isn't as environmentally but it won't mould, or cause other health hazards like the straw would.

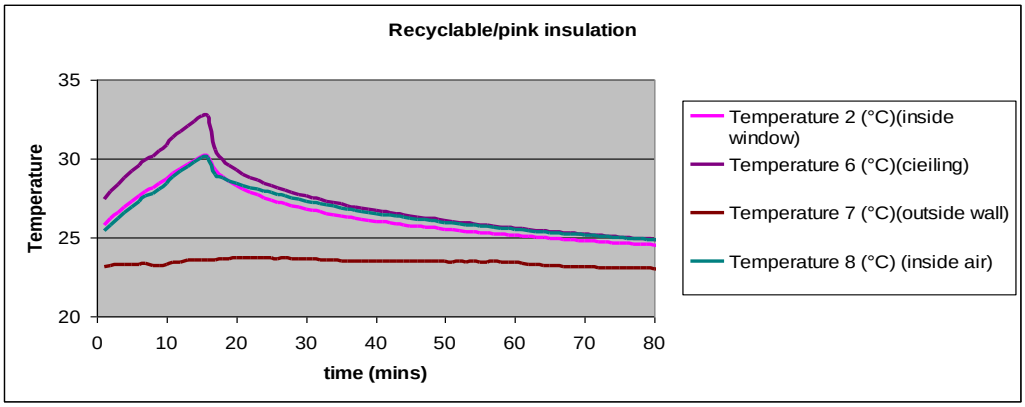
We found the R-Value by research because it can change depending on how thick the insulation is. Therefore, we researched and discovered the R-Value to be 20 for a 2x6 stud. These were the "batts" of insulation that we had purchased, and were testing, so we could compare with the other products.





We chose to test recyclable insulation, for it would be more Eco-friendly compared to the Pink insulation. Recyclable insulation is made up from 87% cellulose recyclable fibre; it also increases your firewall by two hours of protection. You can see that the recycled insulation is just as efficient as the pink insulation. It would cost a lot less and be environmentally friendly. The R-value varies from 12-60 depending on the packing of the insulation.





Construction of our Building

Our building was designed in a standard design to facilitate resale if desired. The floor was constructed with 2'x 6' studs and the walls were standard 2' x 4' studs with 16" centers. The walls were insulated with R20 fibreglass pink insulation. Vapour barrier was installed and covered with 1.5" polystyrene insulation. The polystyrene insulation was added to reduce heat loss through the studs. The shed was also wired with two outlets and lights with a switch to allow everything to run as if the shed were connected to a constant electricity supply. The photos below detail some of the construction phase as it was performed by our Framing and Sheathing class.

Energy Requirements

AC Devices							
Load	Voltage (V)	Current (A)	Power (W)	Time (h)	Energy (Wh)	Energy Available	
TV	120	0.98	117.6	6	705.6	2784	
Video Games	120	1.13	135.6	6	813.6		
Lights	120	0.22	26	10	260		
Water Pump	120	0.15	18	10	180		
					1959.2		
DC Devices							
Air exchanger Fan	12	0.40	4.8	7	33.6	264	
Heater Fan	12	0.40	4.8	8	38.4		
					72		

Solar Panel Supply (4 Panel)

	Current Supply	Time In Sun	Energy Stored
Cloudy Day	4	10	480
Sunny Day	10	10	1200

These are our total Energy Requirements for our Building.

Exterior	
Roof Shingles	$ 180.00
Siding & Trim	$ 325.00
Roof Edge	$ 32.83
Plexiglass	$ 47.46
Paint	$ 18.07
Clear Silicone	$ 25.83
Spray Paint	$ 26.81
Total	$ 656.00

Hardware	
Nails - 3-1/2" 50lb. Box	$ 52.99
Nails - 2-1/2" 50lb. Box	$ 55.95
Staples	$ 3.89
Brackets	$ 3.07
Hose	$ 41.45
Duct Tape	$ 5.07
Aluminum Tubing	$ 28.00
Coupling	$ 4.68
Adapter	$ 16.53
Hose Clamps	$ 28.50
Hose Straps	$ 7.89
Box of Screws	$ 3.59
Box of Zip ties	$ 4.05
Bag of Cellulose	$ 9.25
Hose Coupling	$ 6.44
"Y" - Connectors	$ 1.90
Flex Hose	$ 4.51
Thermostat	$ 12.79
Hose Connectors	$ 11.62
Hose - 100 ft.	$ 39.71
Total	$ 341.88

Lumber	
2x6x96 Stud	$ 92.32
2x6x12 BTR	$ 10.80
OSB 5/8"x4x8	$ 46.20
2x4x96 Stud	$ 123.10
6x6x12 Pressure Treated	$ 71.04
2x4x10 BTR	$ 56.00
OSB 7/16"x4x8	$ 138.00
2x4x12 BTR	$ 6.72
1x6x12 - 2pc.	$ 10.00
Total	$ 554.18

Lighting	
Solar Batteries	$ 550.00
14-2 Roll of Electrical Wire	$ 47.45
Total	$ 597.45

Insulation	
R20x15 78.3Sqft.	$ 289.67
5x4x8 Polybead	$ 172.25
Barrier/Vap	$ 30.87
2x4x8 Polybead	$ 56.97
Sealant 300ml.	$ 9.96
Total	$ 559.72

Project Total	**$ 2,709.23**

Here are our total expenses for the shed.

We plan to take pictures and place our add on kijiji. We want 3000 dollars for our building and if we get no offers, we plan to keep the shed as a test shed.